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AN ANALYSIS OF THE ECONOMIC INCENTIVES FOR NONPOINT TO POINT NUTRIENT CREDIT TRADING IN PENNSYLVANIA

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ABSTRACT

Nutrient credit trading in the Chesapeake Bay watershed provides agricultural producers an opportunity to implement conservation practices on their farms and receive economic benefits for nitrogen and phosphorus pollution reduction into the Bay watershed. This thesis explores the history of the trading program and synthesizes research gathered on the effectiveness of nutrient abatement efforts from nonpoint sources. Recent changes to the nonpoint-point trading ratios have disincentivized nonpoint source participation in the program. These changes were precipitated over concerns that the calculation methodology for nonpoint nitrogen and phosphorus reductions was insufficient in capturing true reductions from agricultural sources. Until new calculation procedures are developed, a 3:1 trading ratio has been implemented in the interim. Producer participation data indicates that the change has reduced enrollment in the trading program.

In supplement to the nutrient trading initiative, cost-share conservation programs provide additional funding for agricultural producers to benefit from nutrient emission reduction efforts. This thesis further explores the effectiveness of cost-share programs, particularly when implemented on an agricultural operation also generating tradable nutrient credits. While the trading program is undergoing structural changes, it is likely that cost-share programs are more cost-effective in limiting nutrient runoff into the Bay watershed. Included are recommendations for greater funding for conservation cost-share programs to fuel farmer integration of best management practices from which they may economically benefit.

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Chapter 1

Introduction

1.1 Overview

Pollution in the Chesapeake Bay has long been an environmental issue. An estuary with a watershed encompassing the greater parts of Maryland, the District of Columbia, Virginia and Pennsylvania, as well as sections of New York, West Virginia and Delaware, the Bay supports a variety of economic activity, including crab and oyster harvesting, commercial fishing, and recreation. As an answer to growing concerns regarding unsustainable levels of nitrogen, phosphorus and sediment loads, the U.S. Environmental Protection Agency (USEPA) implemented a Total Maximum Daily Load (TMDL) in 2010 under direction of the Obama Administration. The TMDL serves as a limit on the amount of nutrient and sediment runoff that enters the Chesapeake Bay in order to meet established water quality standards. An extension of the Clean Water Act, states within the watershed are required to have implemented methods to achieve, at minimum, a 25% reduction in nitrogen and phosphorus loadings and a 20% reduction in suspended sediment loadings by the year 2025 (U.S. EPA, 2010).

Approximately 40% of the entire watershed is located within the Commonwealth of Pennsylvania, as the Susquehanna and Potomac rivers serve as main arteries leading into the Bay (NRCS, 2016). To encourage nutrient runoff mitigation practices, the Commonwealth of Pennsylvania has authorized a nutrient credit trading system in which credits may be traded between nonpoint (agricultural) origins and point (industrial and municipal) sources. Through a system of certification, verification and registration, Pennsylvania agricultural producers within the Chesapeake Bay watershed are eligible to receive credit for (1) best agricultural land management practices, such as conservation tillage or no-till, (2) manure nutrient destruction or conversion processes or (3) exportation of manure to areas outside of the watershed, provided that the producers meet baseline requirements. These credits may then be traded via an online platform supported by the Pennsylvania Department of Environmental Protection (PADEP). Once verified, the credits may be traded at a price determined by private sale or at an auction to point polluters, such as wastewater treatment plants. The wastewater treatment plants, administered by municipal authorities or industries, may use the credits to offset nutrient loads into waterways that are above the levels determined acceptable by the PADEP. This system of credit trading was established exclusively to encourage best nutrient management practices on farms and mitigate nutrient runoff into the Bay watershed.

As noted, for agricultural operations to be considered eligible for credit trading, farms must meet legal baseline requirements. Enforced by PADEP, agricultural operations must comply with the following state erosion and nutrient management laws prior to being considered for credit trading eligibility:

1. All plowing and tilling activities must implement and maintain Best Management Practices (BMPs) to minimize the potential for accelerated erosion and sedimentation. Written erosion and sedimentation control plans are required for agriculture plowing or tilling or animal heavy use areas that disturb 5,000 square feet or more.

2. Farmers must comply with nutrient regulations related to land application of animal manure.

3. Concentrated Animal Feeding Operations (CAFOs) must obtain National Pollutant Discharge Elimination System (NPDES) permits and develop a Nutrient Management Plans authorized by the State Conservation Commission.

Once the baseline requirements are met, agricultural producers can begin generating nutrient credits after implementing the following threshold eligibility requirements:

1. Manure is not mechanically applied within 100 feet of a perennial or intermittent stream with a defined bed or bank, a lake or a pond, and commercial fertilizer is applied at or below appropriate agronomic rates.

2. A minimum of 35 feet of permanent vegetation is established and maintained between the field and any perennial or intermittent stream. No mechanical application of manure may occur within the 35-foot vegetative buffer.

3. A downward adjustment of at least 20% to the overall amount of pollution reduction generated by the pollution reduction activity (PADEP, 2016).

Launched in 2004, the Pennsylvania nutrient credit trading program has undergone a series of changes since its inception. Most notably, the ratio of nonpoint credits that are considered equivalent to a point-generated credit has increased from 1:1 to 3:1. This shift occurred over concerns from the USEPA that (1) Pennsylvania was failing to meet TMDL reduction targets and (2) the certification calculations for nonpoint credits were insufficient in capturing accurate nutrient reduction levels. Pressure from the USEPA prompted the PADEP to change the ratio, lowering the economic incentives for agricultural producers to participate in the program. Participation to date in the credit trading program has fluctuated, highlighted by volatility in credit price movements. Baseline requirements for farmer participation eligibility are set forth by the PADEP, instituting an additional level of requirements for producers to benefit from the program. Although the bulk of participants in the program report some method of best land management practices, several agribusinesses and ancillary service providers have established manure incineration systems and capacity to export nutrient-rich poultry litter to other states in order to benefit from the credit trading program. From an economic perspective, point-nonpoint trading is also designed to reduce the costs of achieving a given nutrient reduction goal, which, in this case, is the TMDL.

Credit prices are determined through private sales and the PADEP's competitive bidding program. The credit values fluctuate significantly throughout the PENNVEST auction process. Due to the 3:1 accreditation ratio, the on-farm value of engaging in credit trading has decreased the last year. PENNVEST nutrient credit auction is the forum that largely dictates credit pricing. Due to inconsistent demand since public trading began in 2010, prices have ranged from a low of $0.47/credit to a high of $7.90/credit. The seven-year average price is $2.72 per credit (PA DEP, 2017). Most credit buyers are municipal sewage treatment facilities, nutrient credit brokers and electric utility providers. These entities purchase credits to counterbalance nutrient and sediment loadings above the waste-load allocation. It is assumed that point sources with a high cost per ton of reducing nutrient runoff into the watershed will trade with nonpoint sources that require a lower cost per ton of nutrient runoff reduction. In theory, price is determined at a point where buyers (point polluters) and sellers (farmers engaged in best land management practices) both stand to benefit from the nutrient credit trading program.

Table 1.1: *Nonpoint nutrient credits registered during CY 2017*

Pollutant Reduction Activity	**Nitrogen Credits**	**Phosphorus Credits**
Poultry Litter Export	216,513	27,064
Poultry Litter Combustion/Gasification	1,051,570	58,853
Best Land Management Practices	82,811	-
Total	1,350,894	85,917

Source: Pennsylvania Department of Environmental Protection Nutrient Credit Registry

To illustrate the division of nutrient credits registered from nonpoint sources for calendar year 2017, Table 1 provides a breakdown how many credits were verified in Pennsylvania. The abatement activity that accounted for the vast majority of both nitrogen and phosphorus credits distributed to agricultural producers were classified as either poultry litter export or combustion/gasification. Throughout calendar year 2017, zero nonpoint phosphorus credits and only 6.13% of total nonpoint nitrogen credits were attributed to best land management practices other than manure export or combustion (PA DEP, 2017). These land management practices were classified as conservation tillage, cover crops, riparian forest buffers, off-stream watering with fencing, precision grazing, horse pasture management, and/or grass buffers.

1.2 Purpose

The purpose of this study is to condense and synthesize available research and data to understand if a change in the credit ratio has had a tangible impact on farmer participation. By identifying and better understanding producer motivations for participation in the nutrient credit trading program, environmental regulators and policymakers alike would be able to structure incentive programs in a manner conducive to increased participation. This exploratory study will rely on a combination of literature review and comprehensive quantitative data from the PADEP's publicly-accessible auction history database.

The objective for this thesis is to answer the following questions:

1. Is the current 3:1 nonpoint to point source trading ratio a sufficient economic incentive for agriculture producers to actively integrate runoff mitigation practices without additional benefits?

2. Would a state-funded cost-share program to subsidize the development of best land management practices and riparian buffers increase farmer participation in the credit trading program?

Nonpoint to point nutrient credit trading provides an opportunity for Pennsylvania agricultural producers within the Chesapeake Bay watershed to play a role in mitigating nutrient and sediment runoff that contributes to eutrophication and pollution in the Bay. Encouraging producers to modify production practices that may ameliorate the effects of nutrient runoff is a proactive step PADEP may undertake to meet the benchmarks set forth by the USEPA. Structural changes to the program may be necessary to encourage increased participation in the nutrient credit trading program. In the face of uncertain economic outlook for the greater part of the agricultural industry, additional income from tradable nutrient credits may prove to be a valuable opportunity to diversify farm income.

Chapter 2

Review of Literature

2.1 The History of Abatement Efforts in the Chesapeake Bay

Prior to focusing on the issues related to the current nutrient credit trading program, it is important to review existing literature on the history of nitrogen and phosphorus reduction efforts in the Chesapeake Bay watershed. In June 2014, the U.S. Department of Agriculture's Economic Research Service (ERS) published *An Economic Assessment of Policy Options to Reduce Agricultural Pollutants in the Chesapeake Bay*, which reviews the policy goals leading to the TMDL and subsequent nutrient accreditation systems. The report uses data from the NRCS's Conservation Effects Assessment Project (CEAP) to simulate nutrient emissions into the Chesapeake Bay watershed and to estimate the associated costs of improved nutrient management for agricultural producers. Further, the report captures data from a number of sources to "build a model to evaluate different policy scenarios for meeting TMDL goals, subject to policy constraints" (Ribaudo, Savage, & Aillery, 2014).

The ERS report begins by citing data from the U.S. Environmental Protection Agency and the Chesapeake Bay Program to highlight the importance of the economic activity generated as a result of the Chesapeake Bay's numerous aquaculture and ancillary industries. Imperiling the continued economic viability of the region is the prevalence of "low oxygen levels, algal blooms, decreased water clarity, loss of submerged aquatic vegetation, and declines in fish and shellfish populations" (U.S. EPA, 2011). Per the Chesapeake Bay Program, only 38 percent of the Bay and the expanded watershed were noted as in compliance with the Clean Water Act standards for dissolved oxygen. Further, the report found that more than 50 percent of the stream health scores, which were calculated at monitoring sites within the watershed, could be registered as “poor” (Chesapeake Bay Program, 2011).

For decades, the Clean Water Act had been largely successful in limiting pollution from point sources, such as factories and wastewater treatment facilities. Confounding the efforts to restore the Chesapeake Bay’s water quality to an appropriate level indicated by the USEPA was the issue of dealing with nonpoint nutrient sources, namely agriculture and stormwater runoff. The history of Bay cleanup efforts officially began in 1983 under the authority of the Chesapeake Bay Program. Organized by leadership from Maryland, Pennsylvania, Virginia, West Virginia, Delaware, New York, and the District of Columbia, the initial plan set forth nutrient and sediment reduction goals with limited strategy and little power to achieve the stated benchmarks (Ribaudo, Savage, & Aillery, 2014). It is estimated that the program has had only minor success in reducing nutrient and sediment loadings, as the poor water quality status and “biological health” of the Bay remained largely the same through 2009 (Chesapeake Bay Program, 2011). Little more than an official acknowledgement of the pollution problem, the 1983 Bay agreement had limited methods of enforcing runoff limitations. Growing concern over the issue was brought to the forefront when formally addressed on the federal level.

In an answer to the slow Bay restoration progress, the President Barack Obama issued the Chesapeake Bay Protection and Restoration Executive Order in 2009 to enhance efforts to clean up the watershed. Shortly thereafter, the USEPA established the Total Maximum Daily Load to “set emission limits for nitrogen, phosphorus, and sediment across the Bay jurisdictions that are believed necessary to meet applicable water quality standards in the Bay and its … rivers and embayments" (Ribaudo, Savage, & Aillery, 2014). TMDLs were first implemented under provisions of the Clean Water Act, but the Chesapeake Bay watershed TMDL was larger in scope and size than any previous TMDLs established nationwide. The mandate was the first to be divided in three nutrient-specific TMDLs for a single area – nitrogen, phosphorus, and sediment - and include a multi-jurisdictional watershed area as large as the Chesapeake Bay (Hoornbeek, Hansen, Ringquist, & Carlson, 2012).

Provisions of the TMDL included a "basinwide [reduction] in nitrogen, phosphorus, and sediment of 25 percent, 24 percent, and 20 percent from 2009 loads, respectively" by the year 2025 (U.S. EPA, 2010). As a method of accountability, the Clean Water Act notes that each state must report to Congress their progress in meeting water quality standards under the TMDL (White House, 2009). The TMDL has been a controversial issue since its implementation. Voluntary nutrient reductions by states had been insufficient and the federal TMDL mandate was established without federal funding directly tied to the regulation. Although Watershed Implementation Plans (WIPs) were developed for states in the Chesapeake Bay watershed, there is wide uncertainty about the mandatory nature of the TMDL and the noticeable lack of funding available for states to achieve the nutrient load reduction goals (Copeland, 2014). The WIPs are intended to identify "specific reductions and control measures to achieve needed pollutant reductions from point sources … and nonpoint sources. The WIPs are part of the accountability framework for the Bay TMDL" (Copeland, 2014). These plans are divided into phases, or increasingly more aggressive reduction measures, until 2025. It is the intention of USEPA to allow states to integrate flexibility into their nutrient loading mitigation programs, hence the individual state WIPs. Despite this, the USEPA has developed a series of "backstops" in the event that a state is unable to achieve the loading reduction goals, including the expansion of permits to currently unregulated areas, placing conditions on USEPA grants, or increasing federal enforcement. The backstops have been controversial, as nutrient reductions under previous TMDLs have been largely based on stakeholder agreements and collaborative efforts (Copeland, 2014).

Exacerbating controversy surrounding the Chesapeake Bay watershed TMDL, little guidance for control measures and no direct funding for reduction efforts were developed by USEPA. Legal action brought against USEPA from agricultural and business groups alike assert that the agency has overstepped its authority granted under the Clean Water Act. The legality of the USEPA's actions were upheld in court, yet tensions still remain (Copeland, 2014). Subsequently, it is highly unlikely that TMDLs for the watershed will be met by 2025 based on current reduction levels and inadequacy of states to develop enforceable WIPs (Nelson, 2014).

To date, states within the Chesapeake Bay watershed, notably Pennsylvania, have struggled to meet pollution abatement benchmarks. This is due, in part, to the difficulties arising from limiting nonpoint source nitrogen and phosphorus runoff. Per a report from the National Academy of Sciences published in 2011, crop and animal production alone contribute approximately 38 percent of total nitrogen loads, 45 percent of phosphorus loads, and nearly 60 percent of sediment loads into the bay, as of 2007 (National Research Council, 2011). Despite the agricultural industry's disproportionate share of nutrient and sediment loading into streams and rivers, there are currently no permitting requirements for crop production and minimal requirements for concentrated animal feedlot operations. Since the USEPA estimates that only 49 percent of nitrogen and 35 percent of phosphorus entering the Bay fall under federal regulations, the remaining pollutants entering the watershed are only subject to state policies or purely voluntary streambank buffer and conservation programs administered by USDA (U.S. EPA, 2010). As a result, nearly half of the pollutants flowing into the Bay can only be limited through voluntary agricultural producer participation in conservation land management practices.

Upon drafting a Watershed Implementation Plan (WIP), the officials from the PADEP heavily relied on the influential conservation cost-share programs as the leading vehicle for reducing nonpoint nutrient runoff. Despite the efforts and high expenditures for the programs, the NRCS estimates that “nearly 90 percent of cropland within the Bay watershed is in need of additional nutrient or sediment management measures” (USDA NRCS, 2011). As a result, states have turned to nutrient credit trading programs as an alternative to limit nonpoint source pollution.

The basis of nutrient credit trading programs is that point polluters, such as sewage treatment plants and factories, may purchase registered and validated credits from agricultural producers employing conservation practices in order to offset the point polluter’s nitrogen and phosphorus loading into the watershed. This method provides flexibility for point sources to comply with maximum runoff regulations while simultaneously providing financial incentives for agricultural producers to implement best conservation land management practices on their farms (Ribaudo, Savage, & Aillery, 2014). Although the practice of trading point to point credits is common throughout the entire Chesapeake Bay watershed, nonpoint to point credit trading is much more difficult to enforce and monitor progress, setting up a number of challenges.

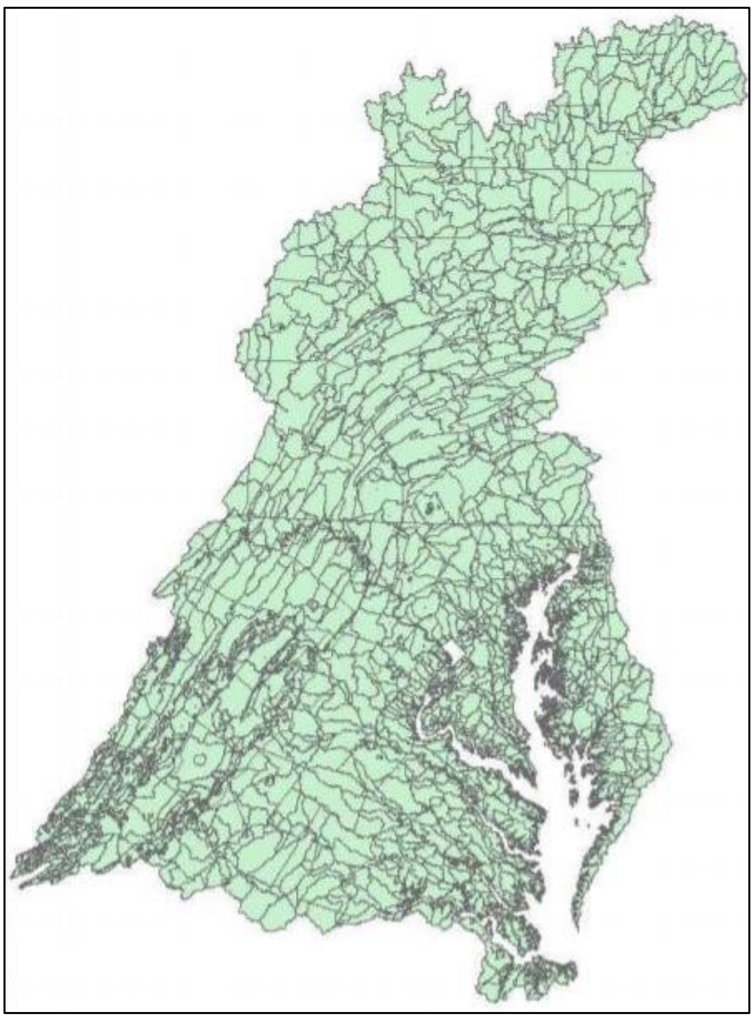
2.2 Challenges Associated with Limiting Nonpoint Pollution

As previously noted, limiting pollution from point source locations is substantially easier to monitor and implement than restricting nitrogen and phosphorus runoff from nonpoint sources. In terms of agricultural production within the Chesapeake Bay watershed, there is little homogeneity between agricultural production practices, soil types, and topography - all of which translate into an administrative challenge to regulate (Vieth, Wolfe, & Heatwole, 2004). Noted throughout the literature is the understanding that a policy regarding nonpoint pollutant regulation is only cost-effective when it accounts for the vast variation in each landowner's relative impact on water quality and associated abatement costs (Babcock, Wu, & Zilberman, 1997).

To illustrate large regional differences, NRCS established Hydrologic Unit Codes (HUC) for divisions between the various river watersheds that flow into the Chesapeake Bay. The codes are used as a classification system to catalog watersheds boundaries and provide a method of identifying subregions that encompasses the area drained by a river or tributary system. Per the NRCS, "per-acre losses of nitrogen, phosphorus, and sediment [eventually leading into the Chesapeake Bay] are highest in the Susquehanna watershed, followed by the Potomac watershed" (USDA NRCS, 2011). Both watersheds extended into Pennsylvania, with the Susquehanna watershed compensating the most area, with a very small portion of the Upper Chesapeake HUC reaching into the southeastern part of the Commonwealth. In total, nearly 40% of the Chesapeake Bay watershed is entirely located with Pennsylvania (NRCS, 2016), placing disproportionate pressure on Pennsylvania land owners to mitigate nutrient and sediment emissions.

Further indicating wide heterogeneity between soil types, agricultural production methods, and topography in the Chesapeake Bay watershed, the USEPA utilizes land-river segments to differentiate between varying land areas and watershed areas, depending on what types of nutrient flows are emanating from a particular segment. There are 2,426 land-river segments in the watershed that have some form of agricultural production. Illustrated in Figure 2.1, 582 of these segments are located in Pennsylvania (Kaufman, et al., 2014).

Figure 2.1: *Chesapeake Bay Watershed by Land-River Segments*



Source: USEPA Environmental Protection Agency GIS Data

Even with the land-river watershed divisions, however, uniformity of agricultural lands is uncommon. Individual agricultural producers may employ a variety of different practices on their operations. USEPA identifies 16 different types of agricultural land uses, ranging from animal feeding operations, row crops, hay, pasture, degraded riparian pasture, and high- and low-tillage areas (Kaufman, et al., 2014). It has been repeatedly noted throughout the literature that "runoff does not emanate from a single point, but leaves each field in so many places, often unseen, that accurate monitoring would be prohibitively expensive" (Ribaudo, Savage, & Aillery, 2014). Intuitively, this issue interferes with the development of sound nonpoint source policy with adequate provisions to limit nutrient and sediment loadings.

Per a study published in the *Journal of Economic Surveys*, accurate observation and metering of runoff from agricultural land and industrial establishments following a heavy rain event is extremely difficult and prohibitively expensive due to the diffuse nature of nonpoint emissions. Traditional methods of monitoring runoff from point sources are not sufficient in adequately capturing nutrient and sediment loadings emanating from nonpoint sources (Shortle & Horan, 2001). Expanding upon the issue, the question arises of which nonpoint polluters are to be targeted. Since methods of accurately calculating where nonpoint runoff is greatest are limited, it is equally difficult to distinguish which tracts of land should be subject to greater emission-control policies. Differences in topography and distance from rivers and tributaries create an abundance of issues for policymakers to identify the relative impact that a nonpoint polluter eventually has on the nitrogen and phosphorus emissions that end up in the Chesapeake Bay. Shortle and Horan note that, even once appropriate methods of identifying the most prolific nonpoint polluters can be identified, a larger problem arises: the method of changing agricultural production practices and ensuring water quality objectives are met (Shortle & Horan, 2001). This is the crux of the debate surrounding nonpoint runoff solutions.

It is the general consensus of the research community that there are four basic approaches to resolving the nonpoint pollution issue: “(1) education programs …, (2) research and development programs to create environmentally friendly and profitable innovations, (3) direct regulations, and (4) economic incentives” (Shortle & Horan, 2001). Educational programs could be implemented in the form of technical assistance for agricultural producers. To date, limited funding has been made available for Pennsylvania to integrate educational programs or research and development grants. As noted, establishing regulations for nonpoint polluters would likely translate to a monumental logistical and administrative challenge. Several regulations regarding nutrient and pesticide management are already in effect for agricultural producers that have not been directly related to the TMDL, including restrictions on crop protection applications. Throughout the Chesapeake Bay watershed, only one of the four options condensed by Shortle and Horan has been implemented to any substantial results: economic incentives.

In Pennsylvania, the economic incentives available for agricultural producers are largely limited to cost-share subsidies for best land management and conservation practices and the nutrient credit trading system. It is generally accepted that the ideal policy would indeed incentivize the reduction of pollutant emissions to the Bay (Oates, 1995). Creating appropriate economic incentives that are successful in reducing the nutrient and/or sediment loadings into the watershed is a challenge in itself. Although emission monitoring tools are available, such as NRCS’s Nutrient Tracking Tool and the Agricultural Policy Environmental Extender (APEX), the design of the models require that the surveys are completed on each individual agricultural operation. Moreover, there is a degree of uncertainty associated with the models that would likely need to be incorporated into any findings (Ribaudo, Savage, & Aillery, 2014). Other methods include the policy options to quantify and limit agricultural inputs or encourage conservation tillage and nutrient management. Providing economic incentives for farmers to limit inputs, such as synthetic fertilizer, would likely be counterintuitive, as agricultural producers would face certain crop yield losses in the event that inputs were restricted. The literature largely finds that the most practical methods of monitoring nonpoint pollution are in the form of encouraging best land management techniques such as conservation tillage and nutrient management (Jackson-Smith, Halling, de la Hoz, & Horsburgh, 2010).

Cost-share programs have been largely successful for agricultural producers seeking to implement structural changes on their operations. Because long-term practices, such as best nutrient management methods, may require long-term economic incentives, it may be in the best interest for the USDA or state conservation districts to provide cost-share opportunities for structural changes, such as the implementation of stream-bank buffers on a farm. The literature has found that "nonstructural management practices, such as nutrient management, are more likely to be discontinued after cost-share funding ends than structural practices" (Jackson-Smith, Halling, de la Hoz, & Horsburgh, 2010). Moreover, agricultural producers may find that incorporating nutrient management practices on their respective operations to be time consuming and logistically challenging.

In *An Economic Assessment of Policy Options to Reduce Agricultural Pollutants in the Chesapeake Bay*, Ribaudo, Savage & Aillery explicate the assertions from previous research on the topic that farmers may not be maximizing net returns. One would expect that, given complete information, the small portion of agricultural producers who increase net returns by integrating conservation practices may instead choose to forego the implementation (Ribaudo, Savage, & Aillery, 2014). The authors theorize that two factors may serve to explain this seemingly irrational phenomenon: (1) only regional average costs were used in the models exploring farmer participation, and (2) uncertainty of expected returns and loss aversion. Nonetheless, all models indicate that most agricultural producers would not be economically incentivized to incorporate land conservation management practices onto their respectively operations without the additional benefit of a cost-share program or similar system of rewarding emissions limiting efforts. The research concludes that TMDL goals could be met through the implementation of land management systems on as little as 12 percent of all cropland within the Chesapeake Bay watershed. Ribaudo, Savage & Aillery suggest that, while questions over policy fairness are sure to be brought into question, "such a tradeoff between equity and efficiency may be necessary to achieve political support for policies that meet TMDL requirements" (Ribaudo, Savage, & Aillery, 2014). Per the research, it appears that the most cost-effective, design-based policy is to locate and target agricultural operations with "moderate" treatment needs and has land adjacent to streams and tributaries within the Bay watershed.

When provided a choice of which best land management practice could be applied on their agricultural operations, farmers generally opted to select conservation methods, such as the use of cover crops and water erosions controls in lieu of nutrient management. It is noted that most farmers acknowledge challenges in setting forth a nutrient management plan that is compatible with their respective farms (Genskow, 2012). Given the wide range of challenges that agricultural producers cite with maintaining nutrient management plans (National Research

Council, 2011), it is evident that other conservation-based practices should be economically incentivized to achieve the TMDL goals.

2.3 Baselines for Nutrient Credit Trading Eligibility

Aside from cost-sharing schemes to incentivize agricultural producers to implement land conservation management practices onto their operations, water quality trading programs are an additional method of encouraging best management practices on farms.

For all states within the Chesapeake Bay watershed, each has a state Watershed Implementation Plan (WIP) that includes provisions for a nutrient credit trading program. The Water Quality Credit Trading Agreement was signed in 2006 as a supplemental measure to incorporate nonpoint-to-point trading into the state action plans (USDA, 2006). Referencing the success realized from air emissions trading, the USEPA has encouraged states to promote nonpoint-to-point trading so that agricultural sources could play a more robust role in keeping abatement costs low while implementing long-term runoff-limiting agricultural practices onto their farms. (U.S. EPA, 2008). However, research indicates that this form of baseline-and-credit programs has not enjoyed similar levels of success as previous cap-and-trade air emissions quality trading systems (Jones & Vossler, 2014). Nonetheless, the nonpoint-point credit trading program has been strongly supported by the USEPA as a method of achieving TMDL goals.

PADEP finalized a Nutrient Trading Policy in 2006, which served as a guideline for the eventual construction of the Nutrient Credit Trading Program in Pennsylvania. Four years later, the agency published its water quality trading program regulations, which were later updated in the *Phase 2 Watershed Implementation Plan Nutrient Trading Supplement*, issued in 2015 (PA DEP, 2016).

Establishing a baseline of requirements for agricultural producers to become eligible for nutrient credit trading is necessary to ensure an adequate offsetting of nutrients into rivers and tributaries. In order for a nonpoint-to-point trading system to be effective, the baseline must set minimum standards so all reductions from nonpoint sources can be calculated in an equitable manner. The integrity of the program is contingent upon accreditation only for nonpoint source pollution reductions occurring after the baseline requirements are met (Ribaudo, Savage, & Aillery, 2014). In short, the volume of nutrient reductions from a nonpoint source must be identical to the foregone reductions from a point polluter.

The USEPA describes the nonpoint baseline requirements as "a prediction of the amount of pollutant emissions from an activity resulting from the expected future behavior of actors absent any policy intervention … holding all other factors constant" (U.S. EPA, 2007). No credits are awarded if the landowner fails to met the baseline obligations. In the event that credits were to be issued for conservation or nutrient management practices already employed by the farmer, the practice would be considered non-additional and total nutrient loadings would be greater than if the credit was not awarded (Marshall & Weinberg, 2012). Within Pennsylvania's nonpoint credit trading policy, the baseline requirement serves as a minimum threshold for agricultural producers to generate credits for nutrient abatement practices employed (U.S. EPA, 2007). Depending on the conservation efforts undertaken by the farmer prior to seeking participation in the nutrient credit trading program or lack thereof, meeting a baseline standard to meet credit trading eligibility may serve to reduce nutrient loadings before a single nutrient credit is certified on the property.

While stringent baseline requirements require agricultural landowners to adopt conservative practices prior to trading credits, the higher requirements may deter some producers from seeking participation in the program. Costs to meet the baseline requirements are likely increase as the minimum threshold standards become more stringent. This would effectively lower the supply of nutrient credits available to point polluters seeking nonpoint credit offsets. Farmers will only participate in the program if the expected credit price is sufficient to cover the costs of establishing baseline requirements plus the additional steps undertaken to generate the credits (Ribaudo, Savage, & Aillery, 2014).

A study completed in the Commonwealth of Virginia found that stringent baseline nutrient credit eligibility requirements for agricultural producers not only may discourage farmers from participating in the program, the "agricultural credit costs for nitrogen can surpass marginal abatement costs for point sources because the baseline has claimed the lowest-cost pollutant reductions" (Stephenson, Aultman, Metcalfe, & Miller, 2010). Further, research completed on Pennsylvania's baseline requirements found that the minimum obligations "significantly increased the cost of entering a trading program" (Gnosh, Ribaudo, & Shortle, 2011), suggesting that agricultural producers may choose to forego participation in the trading program, particularly nonpoint sources with the ability to reduce nutrient emissions at the lowest cost per one credit unit.

Current baseline requirements for nutrient credit trading within Pennsylvania are enforced through PADEP. Minimum qualification standards include the following:

1. All plowing and tilling activities must implement and maintain Best Management Practices (BMPs) to minimize the potential for accelerated erosion and sedimentation. Written erosion and sedimentation control plans are required for agriculture plowing or tilling or animal heavy use areas that disturb 5,000 square feet or more.

2. Farmers must comply with nutrient regulations related to land application of animal manure.

3. Concentrated Animal Feeding Operations must obtain National Pollutant Discharge Elimination System (NPDES) permits and develop a Nutrient Management Plans authorized by the State Conservation Commission.

As previously noted, agricultural producers may already be implementing one or all three of the aforementioned baseline requirements prior to seeking eligibility in the trading program. For example, Concentrated Animal Feeding Operations (CAFOs) are likely to already have established nutrient management plans, per requirements of Pennsylvania's Nutrient Management Act (Act 38), approved by the Pennsylvania state legislature in 2006 (Penn State Extension, 2017). For erosion and sedimentation plans, Penn State extension provides a free online program (PA*OneStop*) and supplemental workshops to agricultural producers for soil mapping and plan development (PAOneStop, 2018).

Beyond the baseline requirements, a second requirement, or "threshold," is defined as either "a 100-foot manure set back, a 35-foot vegetative buffer or a 20 percent adjustment made to the overall reduction" (Environmental Quality Board, 2010). Once agricultural producers seeking eligibility for the program have demonstrated compliance with the baseline and threshold requirements and received approval from PADEP, they may begin generating credits via additional conservation and nutrient management practices.

Depending on current land management practices, meeting minimum baseline and threshold requirements for Pennsylvania agricultural producers may prove to be a costly endeavor. In 2016, PADEP issued the *Phase 2 Watershed Implementation Plan Nutrient Trading Supplement*, which called for enhanced baseline eligibility requirements as a result of USEPA concerns over the PADEP's inability to adequately quantify that the baseline requirements achieve the emissions allocations for nonpoint sources in the TMDL. In lieu of changing baseline and threshold eligibility requirements, PADEP implemented an interim 3:1 trading ratio for all nonpoint credits tradable for point credits (PA DEP, 2016). Despite the USEPA recommendations, the stringency of baseline requirements for nutrient credit trading has not been changed since the implementation of nonpoint-to-point trading in the Commonwealth, resulting in no empirical data comparing participation rates and minimum conservation obligations for program eligibility.

2.4 Process of Generating Nonpoint Nutrient Credits

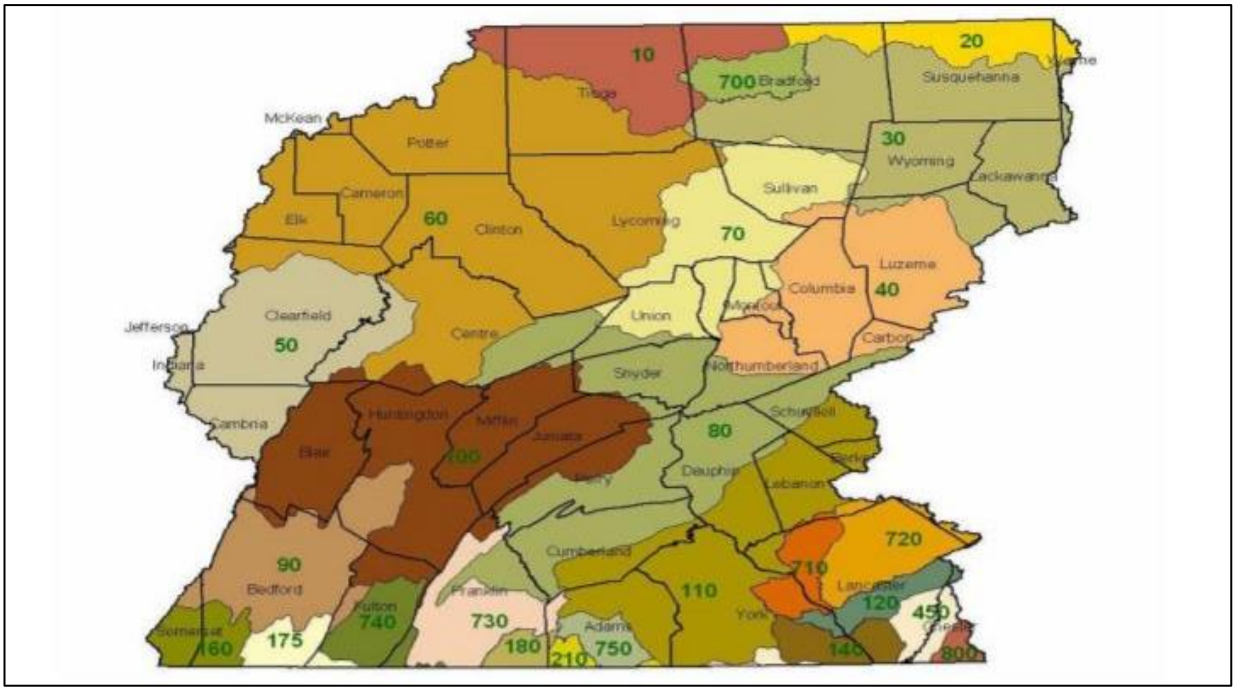
There are a currently three methods of generating nutrient credits from nonpoint sources under provisions of the Pennsylvania Nutrient Credit Trading Program, given that the baseline and threshold requirements have been met: "(1) agricultural best management practices (BMPs), (2) manure nutrient destruction and conversion technologies, and (3) the export of poultry manure (litter) and agricultural application outside of the Chesapeake Bay watershed" (PA DEP, 2019a). Credit generation is achieved through a three-step process of certification, verification and registration. Agricultural operations seeking nutrient accreditation for best management practices must first submit a certification request to PADEP along with a verification plan, or a description of calculation methodology (PA DEP, 2019b). Verification plans require self-validation by the individual responsible for the best management practice and/or verification by a third party, subject to PADEP approval. Options of reducing nitrogen and or phosphorus on a landowner's property may include, but are not limited to, conservation tillage, no-till, reduction in fertilizer application, introduction of streambank buffers, or litter combustion, gasification, and/or export outside of the Chesapeake Bay watershed (PA DEP, 2019c).

Poultry litter that is exported from Pennsylvania must be applied to land outside of the Bay watershed that is "nutrient deficient in accordance with a nutrient management plan of nutrient balance sheet completed by a certified nutrient planner" (PA DEP, 2016). For combustion or gasification systems, incinerated manure is to be tested for nitrogen and phosphorus residue levels prior to calculation of nutrients available for accreditation. To compensate for natural attenuation of nitrogen, phosphorus and sediments as they travel throughout the tributaries in the Bay watershed, a Delivery Ratio is multiplied to the total nutrient reductions on an agricultural property (PA DEP, 2019c). The Delivery Ratio calculation map is outlined in Figures 2.2 and Table 2.1.

Land that is not close to a major river or tributary leading to the Chesapeake Bay is assigned a lower Delivery Ratio, as nutrient loadings must travel farther distances prior to arriving in the Bay, increasing the chance of nutrient attenuation, or loss, in the water. Figure 2.2

assigns regions of the watershed within Pennsylvania with a watershed segment number that corresponds to the appropriate Delivery Ratio indicated in Table 2.1.

Figure 2.2: *Chesapeake Bay Watershed Segment Map*



Source: Pennsylvania Department of Environmental Protection

Table 2.1: *Delivery Ratio Diagram for Nutrient Credit Calculation*

Delivery and EOS Ratios

Watershed Segment	Nitrogen Delivery Ratio	Nitrogen EOS Ratio (see Notes 1 & 2)				Watershed Segment	Phosphorus Delivery Ratio	Phosphorus EOS Ratio (see Notes 1 & 2)			
		Conventional Till	Conservation Till	Hay	Pasture			Conventional Till	Conservation Till	Hay	Pasture
10	0.474	36%	29%	89%	15%	10	0.436	10%	4%	4%	15%
20	0.495	38%	31%	34%	16%	20	0.436	13%	7%	5%	16%
30	0.733	43%	31%	78%	16%	30	0.436	11%	6%	7%	16%
40	0.871	42%	38%	60%	12%	40	0.436	12%	10%	7%	12%
50	0.836	50%	38%	97%	18%	50	0.436	15%	6%	14%	18%
60	0.93	55%	31%	78%	15%	60	0.436	11%	4%	16%	15%
70	0.941	45%	45%	86%	13%	70	0.436	27%	7%	12%	13%
80	0.951	32%	25%	75%	10%	80	0.436	12%	7%	7%	10%
90	0.897	45%	34%	49%	15%	90	0.436	11%	4%	12%	15%
100	0.88	35%	29%	32%	12%	100	0.436	8%	3%	5%	12%
110	0.961	31%	22%	27%	10%	110	0.436	9%	5%	5%	10%
120	0.98	29%	21%	20%	9%	120	0.436	8%	3%	4%	9%
140	0.99	30%	22%	22%	9%	140	0.436	25%	10%	7%	9%
160	0.583	33%	28%	59%	23%	160	0.67	32%	27%	7%	23%
175	0.7	33%	22%	29%	20%	175	0.67	5%	5%	6%	20%
180	0.819	34%	38%	58%	9%	180	0.67	9%	7%	4%	9%
210	0.72	46%	33%	40%	10%	210	0.669	11%	7%	7%	10%
450	1	30%	22%	16%	9%	450	1	5%	2%	2%	9%
470	1	25%	17%	23%	6%	470	1	22%	3%	3%	6%
700	0.7	40%	35%	37%	13%	700	0.436	7%	6%	5%	13%
710	0.97	28%	21%	15%	9%	710	0.436	6%	2%	2%	9%
720	0.891	27%	21%	16%	9%	720	0.436	6%	3%	3%	9%
730	0.683	23%	22%	43%	11%	730	0.67	15%	8%	6%	11%
740	0.749	21%	17%	50%	12%	740	0.67	12%	8%	8%	12%
750	0.627	47%	33%	38%	10%	750	0.67	13%	7%	5%	10%
800	1	48%	34%	34%	9%	800	1	15%	8%	11%	9%

Notes:
1. The portion of nutrient loads leaving a watershed were estimated by adding the manure, fertilizer, air deposition and mineral/residual nutrient inputs for each watershed and subtracting the estimated crop uptake from the total nutrient inputs. The remaining nutrient loads after crop uptake were then divided by the estimated loads leaving the watershed to calculate the edge of watershed percents.
2. All calculations based on watershed simulations completed by EPA's Chesapeake Bay Program Office.

Source: Pennsylvania Department of Environmental Protection

Once final calculations of nonpoint credits are completed via a spreadsheet provided by PADEP, ten percent of all nonpoint credits generated are sent to the PADEP Credit Reserve, a bank of credits set aside to "address nutrient reduction failures, uncertainty, and to provide liquidity in the market" (PA DEP, 2016). All approved nutrient credits are subject to expiration dates established by PADEP, regardless of when the credits were submitted for verification.

Following credit verification, registration occurs when PADEP reviews and approves a sale agreement between a nonpoint seller and a point purchaser or credit broker. These credits may then be used as a nutrient offset for a point polluter or resold. The sale of the credits is legally allowed under the supervision of PADEP or through the PENNVEST nutrient credit auction process (PA DEP, 2019c). Price of credits are determined through open market negotiations and theoretically represent a price below the annualized cost of implementing expensive pollutant abatement technologies for point polluters and the relative costs of introducing best management practices onto an agricultural operation. To satisfy USEPA concerns that nutrient reductions from best management practices on agricultural operations were not being accurately calculated, PADEP established a 3:1 trading ratio to be applied to all nonpoint nutrient credits in 2016 (PA DEP, 2016). This is to remain in effect until new methods of accurately calculating credits generated from nonpoint sources are placed into effect.

Chapter 3

Impact of the Ratio Change on Farmer Participation

Due to a variety of USEPA concerns over the efficiency of nonpoint-to-point nutrient credit trading, PADEP implemented a 3:1 trading ratio for all nutrient credits generated from nonpoint sources looking to trade with a point source. The stochastic nature of nonpoint nitrogen, phosphorus and sediment loadings into waterways is inevitable, as the agricultural pollution abatement efforts are beholden to unpredictable weather patterns (Shortle & Dunn, 1986). A 1993 report, *Point/Nonpoint Source Trading of Pollution Abatement: Choosing the Right Trading Ratio,* explores whether or not a 1:1 ratio is an adequate compensation for uncertainty of nutrient emissions from primarily agricultural lands. As previously noted, it is inherently difficult to accurately measure the true nutrient emissions from nonpoint sources. The study strives to discover a ratio that adequately accounts for uncertainty in the abatement measuring calculations.

The concept of adhering more value to a point credit than a nonpoint credit is not new. In 1991, the USEPA suggested that trading ratios should be set to a value greater than one to “avoid reducing [a point source’s] own loadings by one unit” (Malik, Letson, & Crutchfield, 1993). The Malik, Letson & Crutchfield study adopts this premise and determines how regulators can best calculate a ratio for a given watershed. Per the report, in the absence of accurate or complete information regarding the costs of abatement from nonpoint sources, a regulator could “give the point source a trading schedule … implicitly defined by [an] expected damage constraint, rather than a single ratio” (Malik, Letson, & Crutchfield, 1993). Due to the rapidly escalating complexity of integrating a trading schedule in lieu of a set nutrient credit trading ratio, policy officials have foregone the concept of a sliding scale and settled upon a set trading ratio with the Delivery Ratio to lower administrative time costs.

The Chesapeake Bay Foundation's guidelines for nutrient credit trading suggest a 2:1 minimum trading ratio to "provide a sound justification for deriving expected pollution reductions from the implementation of nonpoint source controls" (Chesapeake Bay Foundation, 2007). This "margin of safety" would likely differ in size depending on the state selected within the Chesapeake Bay watershed, as different states that allow nonpoint-to-point nutrient credit trading have differing baseline and threshold requirements for agricultural landowners.

Theoretically, if the calculation methodology for nutrient verification from nonpoint sources appropriately accounted for uncertainty in weather patterns, the nonpoint-to-point trading ratio would remain 1:1. However, as a temporary measure, PA DEP enforced the 3:1 ratio in 2016 as an interim solution until a more accurate method of calculating nonpoint nutrient abatement is developed (PA DEP, 2016). With the value of a nonpoint credit substantially devalued, one would expect farmer participation in the nutrient credit trading program to decrease. The PADEP is undergoing the process of redeveloping WRI Multi-State Trading Tool in cooperation with the Chesapeake Bay Foundation using solely a performance-based approach. Until the new Trading Tool is unveiled, PADEP will continue to review certification request with the practice-based approach with the 3:1 trading ratio applied to all credits certified for the program. It is important to note that the ten percent nutrient credit reserve deduction is applied *after* the 3:1 nonpoint nutrient credit trading ratio is multiplied to the total sum of nitrogen or phosphorus reductions on the agricultural operation (PA DEP, 2016).

Table 3.1: *Annual Change of PA Nonpoint Source Certified Generators*

Year	Total Nonpoint Source Generators
2014	72
2015	32
2016	48
2017	55
2018	34

Source: Pennsylvania Department of Environmental Protection Nutrient Credit Registry

Indicated in Table 3.1, the total number of certified nonpoint generators has decreased from 72 agricultural operations in 2014 to just 34 in 2018. Following the implementation of the 3:1 trading requirement for certifications after September 30, 2017, the number of certified nonpoint generators decreased from 55 farms to 34 farms in Pennsylvania (PA DEP, 2019a). With only one year of nonpoint source certified generators, the data is insufficient to draw the conclusion that the change in trading ratios has had a direct effect on the number of farms enrolled in the trading program but there is a connection between the integration of the new trading ratio requirements and a decrease in the number of nonpoint trading participants.

The relatively low number of agricultural operations participating in the Pennsylvania nutrient credit trading program is compounded by an equally low median number of nutrient credits generated from agricultural sources. Aside from around 10% of the certified agricultural operations specializing in poultry litter combustion or export, the majority of nonpoint credits are generated from in the implementation of best management practices such as conservation tillage and grass or forest buffer integration. Some of the latter are a result of cost-share programs where farmers are expecting to only earn a return for a portion of the project implementation costs (PA DEP, 2017).

Theoretically, demand for nonpoint credits should materialize when point sources facing high marginal nutrient reduction costs can lower compliance costs by purchasing nonpoint credits. Despite economic studies suggesting that agricultural best management practices are among the lowest-cost methods of reducing loadings (Jones, Branosky, Selman, & Perez, 2010), fewer nonpoint nutrient credits have been traded than expected (Stephenson & Shabman, 2017). Jones et al (2010) finds that the average cost of reducing a pound of nitrogen out of the Bay watershed is estimated to be $15.80/lb./year for a waste water treatment plant. The same volume of nitrogen reduction from either grass buffers, cover crops, or conservation tillage can be achieved for an estimated $10.00/lb./year or less (Jones, Branosky, Selman, & Perez, 2010). Additional studies find even greater cost disparities between urban stormwater runoff mitigation practices and agricultural best management practices. Despite this, the development of a robust nonpoint-to-point credit trading system has yet to materialize.

In Virginia, where nonpoint-to-point nutrient credit trading is also permitted, agricultural credit generation is equally low. A 2:1 credit trading ratio has been implemented in the Commonwealth, which effectively doubles the cost to the point source looking to purchase nonpoint credits. Other variables researchers believe to be contributing to the glaring lack of trading, despite what appear to be obvious economic benefits to agricultural producers and point sources alike, include stringent baseline requirements, much like the credit certification regulations enforced in Pennsylvania (Stephenson & Shabman, 2017). The literature also suggests that the cost of certifying and verifying credits leads to high time costs for agricultural producers seeking to receive accreditation for relatively low volumes of nutrient offsets. Compounded with a 3:1 trading ratio, some farmers may forego implementing best management practices that may only generate minimal revenue (Gnosh, Ribaudo, & Shortle, 2011).

One notable feature of nonpoint-to-point credit trading in Virginia that may discourage point sources from purchasing nonpoint credits is the uncertainty of credits available for sale each year. As a result, buyers have limited assurance that an adequate number of credits would be available over the course of a compliance term. Fluctuation in nonpoint credit supply translate to volatile prices from year to year, often leading point sources to reconsider the costs of installing nutrient abatement technology in lieu of participating in the trading program (Stephenson & Shabman, 2017). Compounding the issue, Virginia requires point sources to comply with maximum nutrient concentration emissions. Although trading can be utilized to meet limits on annual mass loads, “a point source discharger’s numeric concentration limits cannot be modified, amended, or traded, regardless if it is more cost effective to undertake less control onsite” (Stephenson & Shabman, 2017). If a point source fails to comply with the concentration regulation, the ability to trade credits is eliminated and the facility is likely required to install nutrient concentration control technology to bring the point source into compliance. Also notable in the Virginia case study is the capital grant subsidy program available to point sources for nutrient removal technology upgrades at waste water treatment plants. Compounding the concentration compliance requirement and the grant funding available to point sources, the production of tradable point source credits is at a cost competitive with nonpoint source credits. As previously mentioned, the uncertainty of nonpoint credits from year to year may spur point source purchasers to opt for point source generated offset credits, provided that costs are about the same from both sources (Stephenson & Shabman, 2017). Moreover, advancements in waste water treatment technology may reduce the costs of implementing new water treatment systems, creating less demand for tradable credits from both point and nonpoint sources alike (Stephenson, Aultman, Metcalfe, & Miller, 2010).

The case study of Virginia’s nonpoint-to-point nutrient credit trading scheme concludes that the relative lack of agricultural credits generated and traded is only partially due to the cost difference between point and nonpoint sources. The literature concludes that the factors limiting nonpoint credit trade can be attributed to (1) stringent baseline regulations for agricultural source credit generation, (2) water quality program opportunities and grants that disincentive point source purchasers from seeking out nonpoint credits, and (3) the compliance preferences of point polluters, or the desire of point sources to maintain control of nutrient abatement technology rather than rely on purchasing credits (Stephenson & Shabman, 2017). Different regulatory conditions have been prevalent in Pennsylvania, such as different grant programs for waste water treatment plants and, until recently, a 1:1 credit nonpoint-to-point credit trading ratio. Nonetheless, many of the same factors are likely to have driven nonpoint generators from registering credits, such as stringent baseline and threshold requirements. Moreover, point sources may have non-economic motivation to forego purchasing nonpoint credits, such as greater control and certainty over treatment systems installed on the property. The increased 3:1 trading ratio only amplifies the issue of low farmer participation in the program; a trend that is likely to continue into the future.

Chapter 4

Effectiveness of Cost-Share Programs

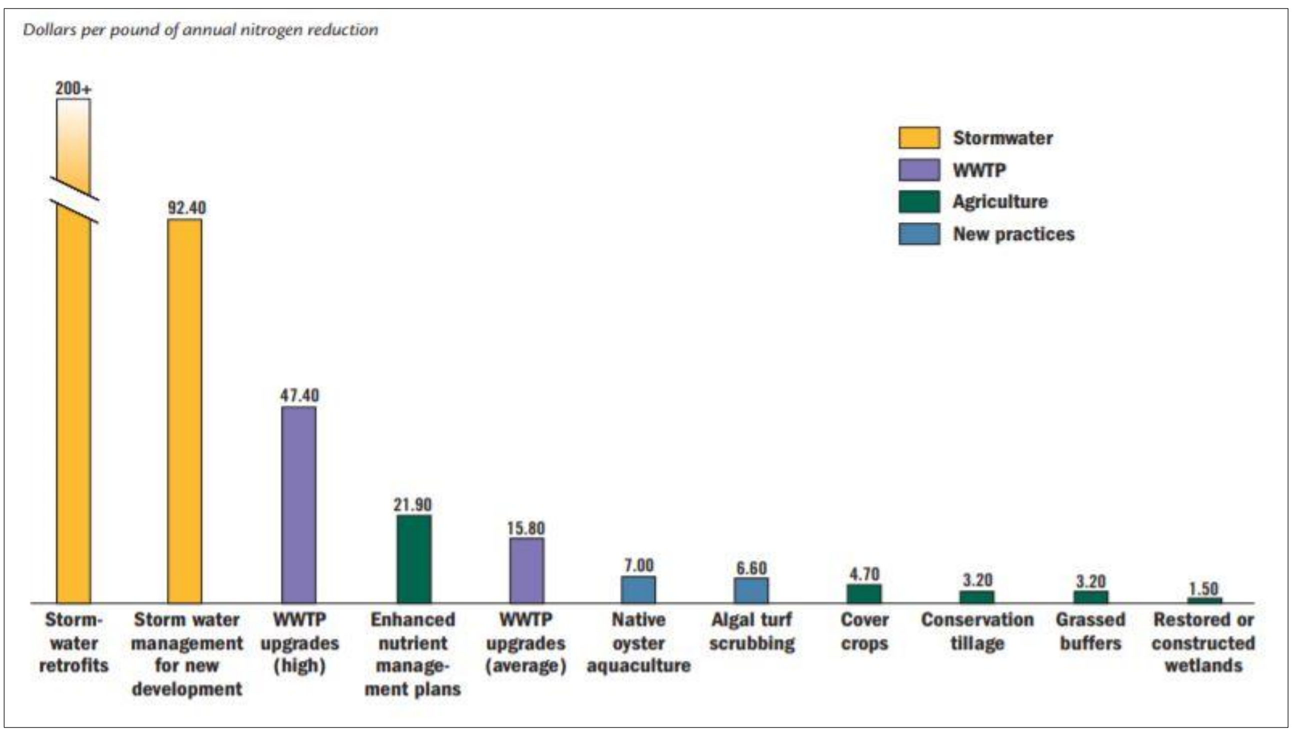
Prior to the establishment of the TMDL, a select few agricultural producers in Pennsylvania took advantage of the USDA's conservation programs, which were typically administered as a cost-share initiative for streambank buffers and fencing or through the Conservation Reserve Enhancement Program (CREP). The latter is a federally funded program, administered through the USDA's Farm Service Agency, where farmers within the Chesapeake Bay are provided financial benefits to keep environmentally sensitive land from agricultural production. State and federal funds are made available for producers willing to keep acreage in the CREP program for a minimum of 10 years and a maximum of 15. The purpose of the program is to reduce erosion and reduce the level of nitrogen and phosphorus runoff into the Bay watershed while restoring and maintaining habitats for wildlife and preservation of wetlands (USDA Farm Service Agency, 2016). Before the implementation of nonpoint-to-point nutrient credit trading in Pennsylvania, research from the World Resources Institute suggested that credit trading alone could replace cost-share programs, provided that the trading program was properly administered and eventually expanded to allow credit trading across Bay watershed state lines (Jones, Branosky, Selman, & Perez, 2010). However, as previously noted, the scale of nutrient credit trading within the Chesapeake Bay watershed has been limited by a variety of reasons, included difficulty adequately calculating the nonpoint credits.

USDA provides funding for two types of projects: structural practices and management practices. The former incorporates multiple types of soil conservation structures, such as terraces, grade stabilization and water basins in addition to buffer practices on the edge of fields.

Management practices include conservation tillage techniques, such as mulch-till, ridge-till, strip-till, and no-till. Funding is also available for nutrient management, which may be defined as a collection of best land practices for ground application of manure (USDA ERS, 2014).

Cost-share programs strive to achieve the same result as nutrient credit trading: limiting nitrogen, phosphorus and sediment emissions into the Chesapeake Bay watershed via best land management practices. An overwhelming amount of data finds that incorporating grass buffers and conservation tillage on agricultural operations is notably more cost-effective than upgrading technology for waste-water treatment plants or attempting to develop systems of limiting stormwater runoff. These values are further demonstrated in Figure 4.1.

Figure 4.1: *Relative Cost of Nutrient Emissions Abatement in the Bay Watershed*



Source: World Resources Institute, *Nutrient Credit Trading Could Help Restore the Chesapeake Bay*

The above data reinforces the concept that the most cost-effective methods of meeting TMDL goals are through agricultural best management practices. Farmers may be hesitant to participate in the nutrient credit trading program due to incomplete information, volatility in the credit market, uncertainty of future baseline and threshold requirements, or simply the high administrative costs of certifying and verifying nonpoint credits for trading purposes (Vieth, Wolfe, & Heatwole, 2004). Cost-share programs have been embraced by agricultural operators in the past, partly due to guaranteed partial funding and the proven success of other farmers that have integrated cost-share projects onto their agricultural operations.

As previously noted, the heterogeneity of land in agricultural production within the Bay watershed means that best management practices on certain lands, particularly ones in proximity to the Chesapeake Bay, are the most cost effective. However, the number of farms with the lowest marginal reduction costs is insufficient to achieve TMDL goals alone. It is estimated that meeting the TMDL goals by 2025 will require agricultural operations from both low and higher-cost land-river segments to integrate best management practices, even prohibitively expensive ones (Kaufman, et al., 2014). Thus, the true dollars per pound of nutrient reduction into tributaries of the Bay is likely to greater than illustrated in Figure 4.1. Regardless, the average cost per pound of nutrient reduction via agricultural best management practices is substantially lower than the average cost per pound of reduction from the implementation of point source abatement technology and/or stormwater runoff reduction infrastructure (Jones, Branosky, Selman, & Perez, 2010).

Similar to nutrient credit trading, participation in cost-share programs is voluntary. The purpose of cost-share programs is additionality, which can be defined as the integration of conservation practices that would not have occurred if cost-share funding was not utilized (USDA ERS, 2014). Due to the voluntary nature of the cost-share programs, it is difficult for researchers to accurately gauge the effectiveness of the program. However, the results that can be ascertained are promising. The USDA's Economic Research Service (ERS) finds that the probability of practice use additionality is very high for government-funded soil conservation practices, buffer practices and nutrient and manure management, with estimated additionalities of 82 percent, 80 percent and 88 percent, respectively. Conservation tillage cost-share programs are not as effective, as only 56 percent additionality is observed following a payment scheme (USDA ERS, 2014).

As for the effectiveness of the programs in terms of nutrient emissions reduction, quantifying accurate values is very difficult due to high variability in weather patterns, topography and calculation methods across the Chesapeake Bay watershed (Fleming, Lichtenberg, & Newburn, 2018). Nonetheless, it is very clear that cost-share programs provide substantial incentive for agricultural producers to integrate best management practices onto their agricultural operations for all agricultural operations. Due to the recent change in nonpoint-to-point credit trading ratio, cost-share programs alone may serve as the best method for farmers to incorporate conservation practices onto their farms and contribute to meeting Chesapeake Bay watershed TMDL benchmarks.

The practice of "double-dipping," or the prevalence of farmers enrolling in both the cost-share program and the nutrient credit trading program simultaneously, has occurred intermittently on Pennsylvanian agricultural operations. Provided that this practice of double-dipping is not prohibited by PADEP, "each program cross-subsidizes the other, and farmers' marginal abatement costs are reduced relative to what would emerge under either program individually" (Horan, Shortle, & Abler, 2004). Intuitively, the ability for agricultural producers to receive funding from both cost-share programs and tradable credits greatly incentivizes participation in the latter's program. However, the cost per pound of nutrient emissions reduction may increase as double-dipping occurs, as government payments into the program may only contribute to an offset of point source pollution in lieu of nutrient emission reduction. However, if payment programs for input-based policies are constructed properly, double-dipping may in fact increase efficiency. This would effectively transfer much of the agricultural payments to point sources as a de facto subsidy (Horan, Shortle, & Abler, 2004). Cost-share programs, if implemented properly in coordination with nutrient credit trading provisions, could provide agricultural producers adequate economic incentives to participate in the combined programs while simultaneously achieving TMDL goals.

Chapter 5

Conclusions

In the midst of an economic downturn for the agricultural industry, incentivizing farmer participation in Chesapeake Bay watershed conservation efforts may prove particularly difficult for policymakers. Nutrient credit trading provides an opportunity for agricultural producers to benefit from best land management practices while offsetting ongoing nitrogen and phosphorus pollution from point sources. However, in the absence of adequate calculation methodologies to accurately measure nonpoint nutrient emissions abatement, the PADEP's implementation of a 3:1 nonpoint-to-point source trading ratio has shifted the math for agricultural producers, effectively lowering the economic incentivizes to participate in the trading program and farmer participant as subsequently following the policy change.

Cost-share programs have been largely successful in shifting agricultural producer land management practices, although gauging exact amounts of nitrogen and phosphorus abatement the programs have driven is inherently difficult due to a variety of land features on each agricultural operation. Provided that carefully targeted cost-share programs are properly administered, the practice of "double-dipping" effectively can pass the farmer subsidies to point polluters via the tradable nutrient credits. This is only probable if best management practices and locations are carefully targeted by PADEP. Although the cost of a cost-share program may be relatively high (Kaufman, et al., 2014), the coupling of nutrient credit trading and increased cost-share programs could simultaneously provide economic benefits for agricultural producers and a means for point sources to offset nutrient loadings via a more robust credit trading system.

With diminished economic incentives to participate in the nutrient credit trading program, policy officials should consider higher funding for cost-share programs for agricultural producers in addition to credit trading to meet TMDL goals for the Chesapeake Bay watershed. This could ensure that the agricultural industry can stand to benefit economically from Bay watershed improvement efforts and set in place best management practices for Pennsylvania farmers far into the future.

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ACADEMIC VITA FOR TONY WESTON RICE

Education

The Pennsylvania State University – Agribusiness Management Major
▪ Political Science Minor
▪ President – Penn State Collegiate Farm Bureau
▪ Former Undergraduate Representative – College of Agricultural Sciences' Instruction and Curricular Affairs Committee

Experience

Agricultural Affairs and Commodity Policy Intern 6/4/2018 – 8/10/2018
Office of the U.S. Trade Representative ▪ 600 17th Street NW, Washington D.C. 20006
▪ Drafted four informational briefs on foreign subsidy programs for the United States' Chief Agricultural Negotiator
▪ Collaborated with staff to formulate model Sanitary and Phytosanitary Standards for potential future trade agreements
▪ Forecasted and quantified the economic impact of tariffs on the domestic agriculture industry

Office of Cabinet Affairs Intern 1/10/2018 – 5/27/2018
White House Internship Program ▪ 1600 Pennsylvania Avenue NW, Washington D.C. 20500
▪ Analyzed current policy issues pertaining to multiple internal departments to ensure uniformity in policy initiatives
▪ Drafted twelve formal "white glove" event memos for Cabinet Officials
▪ Developed an interactive calendar system to track meetings of senior administrative personnel

Governmental Affairs Intern 5/16/2017 – 8/16/2017
Pennsylvania Farm Bureau ▪ 510 South 31st Street, Camp Hill, PA 17011
▪ Compiled seven white papers on issues including nutrient credit trading and grain dealer indemnity funds, among others
▪ Interpreted and advocated Farm Bureau policy in 17 state and federal legislator visits, meetings with the Pennsylvania Department of Agriculture, and informal NAFTA renegotiation stakeholder discussions with Mexican diplomatic personnel

Political Research Intern 6/24/2015 – 8/14/2015
Pennsylvania's 85th Legislative District ▪ 343 Chestnut Street, Suite 1, Mifflinburg, PA 17844
▪ Reviewed and edited 3 draft bills to be later introduced into the PA House of Representatives
▪ Filed, advised, and assisted over 200 constituents on case work

Farm Operations Employee 2/10/2010 – 6/10/2014
Millrace Services, LLC ▪ 140 Millrace Road, Mt. Pleasant Mills, PA 17853
▪ Managed business operations and supervised two employees for a 45 head dairy herd and 180-acre row crop farm
▪ Developed a 15-acre specialty crop division of the family business, primarily sweet corn and pumpkin production
▪ Secured financing and developed direct consumer markets for a 20-head beef herd

Leadership Activities

National Student Advisory Team 5/10/2017 – 4/30/2018
Agriculture Future of America (AFA) ▪ P.O. Box 414838, Kansas City, MO 64141
▪ Traveled the United States in an appointed position, formulating professional development curriculum for 850 competitively selected post-secondary agriculture students, soliciting organizational partnerships with agriculture industry leaders, and mentoring college students through their career path development process

Vice President 6/12/2014 – 11/2/2015
Pennsylvania FFA Association ▪ 2301 N. Cameron St., Harrisburg, PA 17110
▪ Served in a year-long volunteer capacity facilitating professional development workshops for over 12,00 secondary agriculture students, advocating for sound agriculture and education policy, and representing the National FFA Organization's 653,000+ members at the White House Convening on Career and Technical Education

Recognition

▪ Farm Foundation Cultivator Award (2019)
▪ Penn State Office of Student Activities Student Leader Scholarship Recipient (2019)
▪Seaboard American Royal Scholar (2018)
▪National Dairy Promotion and Research Board James H. Loper, Jr. Award (2018)
▪American Farm Bureau Federation Collegiate Discussion Meet Participant (2018)
▪Hart-Parr Oliver Collector's Club Scholarship Recipient and Guest Speaker (2017)
▪Pennsylvania Young Farmers' Association's Spokesperson for Agriculture Award (2017)
▪National Dairy Shrine Scholarship Recipient (2017)
▪Coaly Honors Society Public Speaking Award (2016)
▪American FFA Degree Recipient (2015)